

Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance

F. M. Pestorius & N. Langhorne

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Keywords

Ocean variability, seabed, acoustic, fluctuations, modeling, waveguide, bottom, sonar, signal processing, prediction

1. Introduction

The observation that acoustic propagation is more complex and more difficult to predict, model and analyze in shallow littoral waters has by now become almost a cliché. Nonetheless, it is an accurate observation. This newsletter reports on the above named conference sponsored by the SACANTCEN at La Spezia, Italy and held at the beautiful Villa Marigola in Lerici, Italy during the period 16-20 September 2002. The conference was organized very ably by Nicholas G. Pace and Finn B. Jensen of the SACLANTCEN staff.

Unlike acoustic propagation in the deep ocean which can be modeled in a reasonably confident manner, littoral seas exhibit an almost endless variety of propagation conditions that stubbornly refuse to accommodate model generalization. The interaction of the surface, bottom slope and material, the greater variability of the sound speed profile and the waveguide effects of depth variations all conspire to make shallow water propagation, modeling and prediction a rich area of study, theory and model development. In the words of Pace and Jensen, the conference organizers: "The limiting influence of the environment on sonar has long been recognized as a major challenge to science and technology. As the area of interest shifts towards the littoral, environmental influences become dominant both in time and space. The manifold challenges encompass prediction, measurement, assessment and adaptive responses to maximize the effectiveness of systems. Although MCM and ASW activities are dominated in different ways and scales by the environment, both warfare areas have had to consider the significantly changing requirements posed by operations in the littoral. The fundamental scientific issues involved in developing models relating acoustics to the environment are matched in difficulty by the need for data for their validation and eventual practical use for prediction. In many instances the need is for on-line adaptation of systems to changing circumstances whilst other needs are for the longer term planning activities."

A total of 128 delegates were listed as attending the conference. As may be expected, 65 were from the US (not including those among the 26 listed from SACLANTCEN). 10 delegates were from Canada, 7 from the UK, and with 3 or less from Italy, Germany, France, Sweden, Norway, New Zealand, Turkey, Denmark, South Africa, Belgium, Portugal and Greece. 36 of the delegates were from Universities.

Of the 74 papers presented, 44 were from the US, 12 from SACLANTCEN, 5 from Canada and 4 from the UK (by senior author), leaving 9 from other nations.

The conference was presented in an all-plenary style, thereby relieving the attendees of the often frustrating problem of deciding between equally interesting presentations. Moreover, the organizers had prepared a bound book and CD of almost all the presentations. This newsletter simply lists the presentations and their authors. Readers wishing more detailed information are encouraged to

contact the authors of this newsletter at mpestorius@onrifo.navy.mil or
<nlanghorne@onrifo.navy.mil>

2. Ocean Variability

Acoustic effects of environmental variability in the SWARM, PRIMER and ASIAEX experiments (*Invited paper*)

J. Lynch, A. Fredricks, J. Colosi, G. Gawarkiewicz, A. Newhall, C.-S. Chiu and M. Orr

Acoustic intensity variability in a shallow water environment

B.H. Pasewark, S.N. Wolf, M.H. Orr and J.F. Lynch

Combination of acoustics with high resolution oceanography (*Invited paper*)

J. Sellschopp, P. Nielsen and M. Siderius

Effect of hurricane Michael on the underwater acoustic environment of the Scotian Shelf

D. Hutt, J. Osler and D. Ellis

High-frequency acoustic propagation in the presence of oceanographic variability

M. Badiey, K. Wong and L. Lenain

Instrumented tow cable measurements of temperature variability of the water column

A.A. Ruffa and M.T. Sundvik

Mesoscale – small scale oceanic variability effects on underwater acoustic signal propagation

E. Coelho

Spatial coherence of signals forward scattered from the sea surface in the East China Sea (*Invited paper*)

P.H. Dahl

Variability in high frequency acoustic backscattering in the water column

A.C. Lavery, T.K. Stanton and P.H. Wiebe

3. Seabed Variability

Intra- and inter-regional geoacoustic variability in the littoral (*Invited paper*)

C.W. Holland

Acoustic and *in-situ* techniques for measuring the spatial variability of seabed geoacoustic parameters in littoral environments

J.C. Osler, P.C. Hines and M.V. Trevorrow

Measurements of bottom variability during SWAT New Jersey Shelf experiment

Turgut, D. Lavoie, D.J. Walter and W.B. Sawyer

Mapping seabed variability using combined echosounder and XBPs for sonar performance prediction

K.M. Kelly and G.J. Heald

Variability of shear wave speed and attenuation in surficial marine sediments

M.D. Richardson

In-situ determination of the variability of seafloor acoustic properties:

An example from the ONR Geoclutter area

L.A. Mayer, B.J. Kraft, P. Simpkin, P. Lavoie, E. Jabs and E. Lynskey

Calculation of *in situ* acoustic wave properties in marine sediments

B.J. Kraft, L.A. Mayer, P. Simpkin, P. Lavoie, E. Jabs, E. Lynskey and J.A. Goff

Sub-bottom variability characterization using surface acoustic waves

(Invited paper) M.E. Zakharia

The influence of noise and coherence fluctuations on a new geo-acoustic inversion technique

C.H. Harrison

Estimating shallow water bottom geo-acoustic parameters using ambient noise

D. Tang

Effect of environmental variability on model-based signal processing: Review of experimental results in the Mediterranean *(Invited paper)*

J.-P. Hermand

Rapid geoacoustic characterization for limiting environmental uncertainty for sonar system performance prediction

K.D. Heaney and H. Cox

Environmental uncertainty in acoustic inversion

S.E. Dosso and M.J. Wilmut

Measuring the azimuthal variability of acoustic backscatter from littoral seabeds

(Invited paper)

P.C. Hines, J.C. Osler and D.J. MacDougald

Backscatter from elastic ocean bottoms: Using the small slope model to assess acoustical variability and uncertainty

R.F. Gragg, R.J. Soukup and R.C. Gauss

Spatial and temporal variability in bottom roughness: Implications to high frequency subcritical penetration and backscatter *(Invited paper)*

K.L. Williams, D.R. Jackson, E.I. Thorsos, D. Tang and K.B.

Variability of bottombackscattering strength in the 10–500 kHz band at shallow grazing angles

N.P. Chotiros

Predicting scattered envelope statistics of patchy seafloors *(Invited paper)*

A.P. Lyons, D.A. Abraham and E. Pouliquen

The effect of seabed backscattering variability on the probability of detection and on the performance of seabed classification algorithms

E. Pouliquen, L. Pautet and A.P. Lyons

4. Acoustic Fluctuations: Measurement

Effects of environmental variability on acoustic propagation loss in shallow water *(Invited paper)* *T. Akal*

Broadband acoustic signal variability in two “typical” shallow-water regions

P.L. Nielsen, M. Siderius and J. Sellschopp

Variability, coherence and predictability of shallow water acoustic propagation in the Straits of Florida

H.A. DeFerrari, N.J. Williams and H.B. Nguyen

Ambient noise and signal uncertainties during the summer shelfbreak PRIMER exercise

P. Abbot, C. Gedney, I. Dyer and C.-S. Chiu

Variability effects due to shallow sediment gas in acoustic propagation: A case study from the Malta Plateau *K.M. Kelly*

Acoustic fluctuations and their harmonic structure

R. Field, J. Newcomb, J. Showalter, J. George and Z. Hallock

Group and phase speed analysis for predicting and mitigating the effects of

fluctuations *(Invited paper)*

W.A. Kuperman, S. Kim, G.F. Edelmann, W.S. Hodgkiss, H.C. Song and T. Akal

High-frequency propagation for acoustic communications *(Invited paper)*

M.B. Porter, P. Hursky, M. Siderius, V.K. McDonald and P. Baxley

Channel impulse response fluctuations at 6 kHz in shallow water

W.S. Hodgkiss, W.A. Kuperman and D.E. Ensberg

High resolution analysis of eigenray gain perturbations in ultra-shallow water

S.M. Simmons, O.R. Hinton, A.E. Adams, B.S. Sharif and J.A. Neasham

Impact of flow variability on fixed side-looking 100 kHz sonar performance in a shallow channel

M. Trevorrow

Correlation between sonar echoes and sea bottom topography

J. Wegge

5. Acoustic Fluctuations: Models

Acoustic scattering in wave-covered shallow water. The coherent field

(Invited paper) B.J. Uscinski

Simulations of temporal and spatial variability in shallow water propagation

E.I. Thorsos, F.S. Henyey, K.L. Williams, W.T. Elam and S.A. Reynolds

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Assessing the variability of near-boundary surface and volume reverberation using physics-based scattering models

R.C. Gauss, J.M. Fialkowski and D. Wurmser

Modeling propagation and reverberation sensitivity to oceanographic and seabed variability

K.D. LePage

Uncertainty in reverberation modelling and a related experiment

C.H. Harrison, M. Prior and A. Baldacci

Statistics of the waveguide invariant distribution in a random ocean

D. Rouseff

Effects of environmental variability on focused acoustic fields

B.E. McDonald, J. Lingeitch and M. Collins

Effects of sound speed fluctuations due to internal waves in shallow water on horizontal wavenumber estimation

K.M. Becker and G.V. Frisk

Relative influences of various environmental factors on 50–1000 Hz sound propagation in shelf and slope areas

T.F. Duda

Sub-mesoscale modeling of environmental variability in a shelf-slope region and the effect on acoustic fluctuations

S. Finette, T. Evans and C. Shen

Yellow Sea internal solitary wave variability

A. Warn-Varnas, S. Chin-Bing, D. King, J. Hawkins, K. Lamb and M. Teixeira

Four-dimensional data assimilation for coupled physical-acoustical fields

P.F.J. Lermusiaux and C.-S. Chiu

Source localization in a highly variable shallow water environment: Results from ASCOT-01 (*Invited paper*) *M. Siderius, P. Nielsen and J. Sellschopp*

Experimental testing of the blind ocean acoustic tomography concept

S.M. Jesus, C. Soares, J. Onofre, E. Coelho and P. Picco

Benchmarking geoacoustic inversion methods for range dependent waveguides (*Invited paper*)

N.R. Chapman, S. Chin-Bing, D. King and R.B. Evans

Adjoint-assisted inversion for shallow water environment parameters

P. Hursky, M.B. Porter, B.D. Cornuelle, W.S. Hodgkiss and W.A. Kuperman

Tidal effects on MFP via the INTIMATE96 test *Tolstoy, S. Jesus and O. Rodriguez*

Multipath effect on DPCA micronavigation of a synthetic aperture sonar

L. Wang, G. Davies, A. Bellettini and M. Pinto

Sea surface simulator for testing a synthetic aperture sonar

B. Davis, P. Gough and B. Hunt

Using a faceted rough surface environmental model to simulate shallow-water SAS imagery

A.J. Hunter, M.P. Hayes and P.T. Gough

A study of ping-to-ping coherence of the seabed response

L. Pautet, E. Pouliquen and G. Canepa

Variability of the acoustic response from spherical shells buried in the seabed by model-based analysis of the at-sea data *Tesei, A. Maguer, W.L.J. Fox, R. Lim and H. Schmidt*

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5. Sonar Signal processing & Performance Prediction

Performance bounds on the detection and localization in a stochastic ocean

A.B. Baggeroer and H. Schmidt

Robust adaptive processing in littoral regions with environmental uncertainty

L.M. Zurk, N. Lee and B. Tracey

A robust model-based algorithm for localizing marine mammal transients

C.O. Tiemann, M.B. Porter and J.A. Hildebrand

Assessment of the impact of uncertainty in seabed geoacoustic parameters on predicted sonar performance

M.K. Prior, C.H. Harrison and S.G. Healy

Reverberation envelope statistics and their dependence on sonar beamwidth and bandwidth

D.A. Abraham and A.P. Lyons

The role of nowcast and forecast input parameters for range dependent transmission models

J.S. Sendt, A.D. Jones and J.R. Exelby

Are current environmental databases adequate for sonar predictions in shallow water?

C.M. Ferla and F.B. Jensen

Yellow Sea acoustic uncertainty caused by hydrographic data error

P.C. Chu, C.J. Citron, S.D. Haeger, D. Schneider, R.E. Keenan and D.N. Fox

Detection of sonar induced measurement uncertainties in environmental sensing: A case study with the toroidal volume search sonar

C. de Moustier and T.C. Gallaudet

Environmental variability of the LBVDS sea tests

S. Sutherland-Pietrzak and E. McCarthy

AREA: Adaptive Rapid Environmental Assessment (*Invited paper*)

H. Schmidt

Environmentally adaptive sonar control in a tactical setting

W.L.J. Fox, M.U. Hazen, C.J. Eggen, R.J. Marks II and

M.A. El-Sharkawi

Transfer of uncertainties through physical-acoustical-sonar end-to-end systems:
A conceptual basis

A.R. Robinson, P. Abbot, P.F.J. Lermusiaux and L. Dillman

Sonar performance predictions incorporating environmental variability

P. Abbot and I. Dyer

6. Assessment

Owing the number and diversity of the variables in the littoral environment, together with their changes with different magnitudes of time and space, there is a danger of using poor correlations to draw conclusions on the similarities, or differences, in the environmental conditions in different locations. This seemed to be particularly the case for those working on seabed parameters.

The validity of predictive models of practical use is dependent upon high quality data, together with an understanding of its temporal and spatial variability. To this end, oceanographers, acousticians, sedimentologists, systems engineers, modelers and operators need to continue to work together and benefit from a multi-disciplinary approach, as well as an understanding of the strengths and weakness of their individual contributions.

The conference presented an excellent overview of the problems inherent in considering acoustic propagation in the littoral seas. There was adequate time devoted to each topic area and the pace of the conference was conducive to thorough exploration of the topic.

8. Contacts

Dr. Nicholas G. Pace
SACLANTR Undersea Research Centre
La Spezia, Italy
pace@saclantc.nato.int

DR. Finn B. Jensen
SACLANTR Undersea Research Centre
La Spezia, Italy
Jensen@saclantc.nato.int

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